Skin SST analysis in NASA GEOS Atmospheric Data Assimilation System

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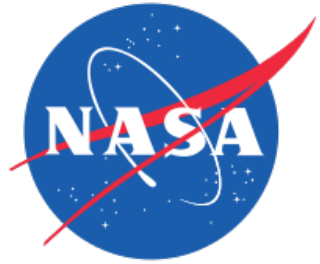
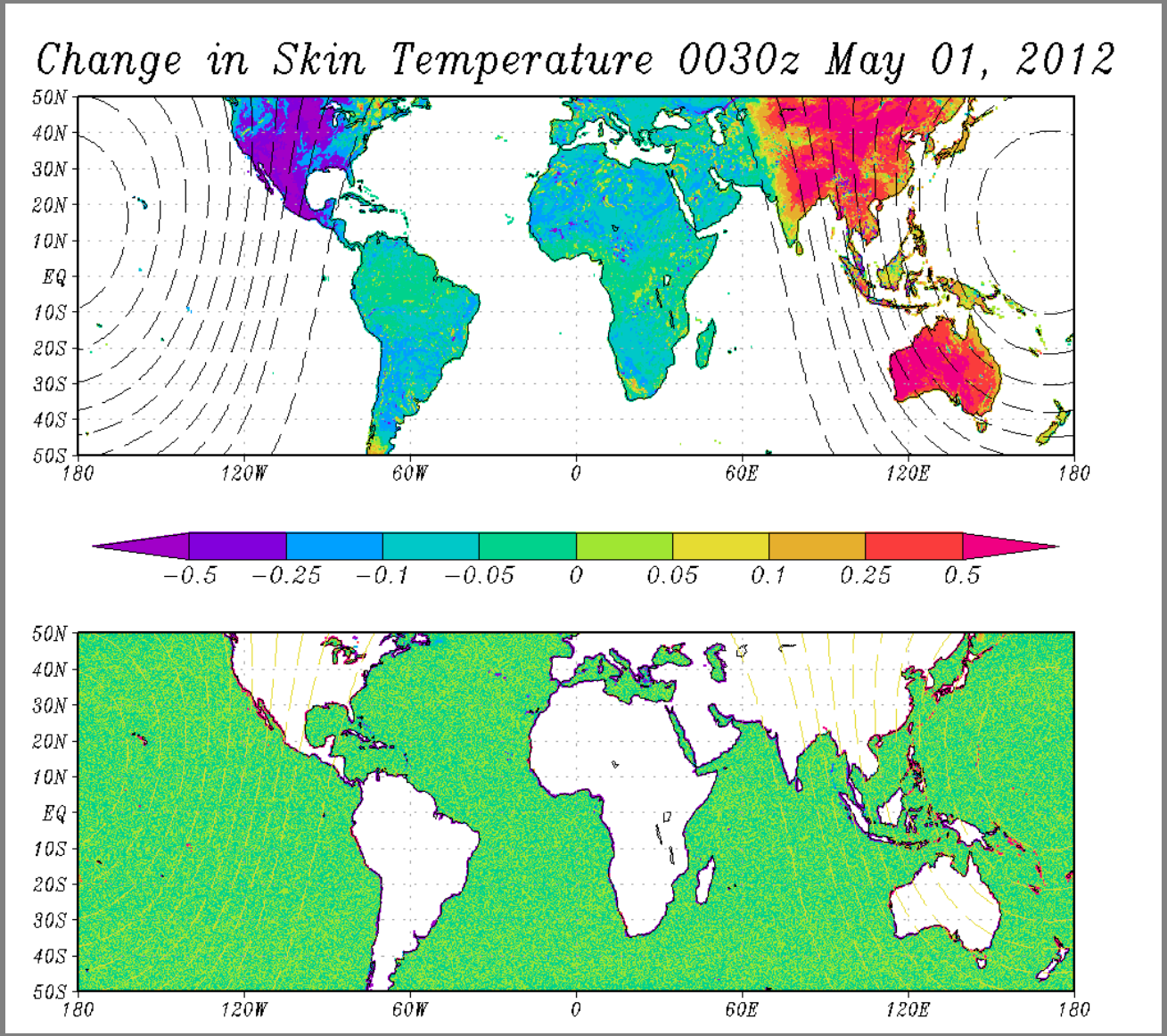


12^{th} *JCSDA Workshop*, College Park, MD. May 23, 2014

Current status of Skin Temperature

Skin SST or atmosphere **lowest level temperature: T_s**



changes over land

but *not* over ocean

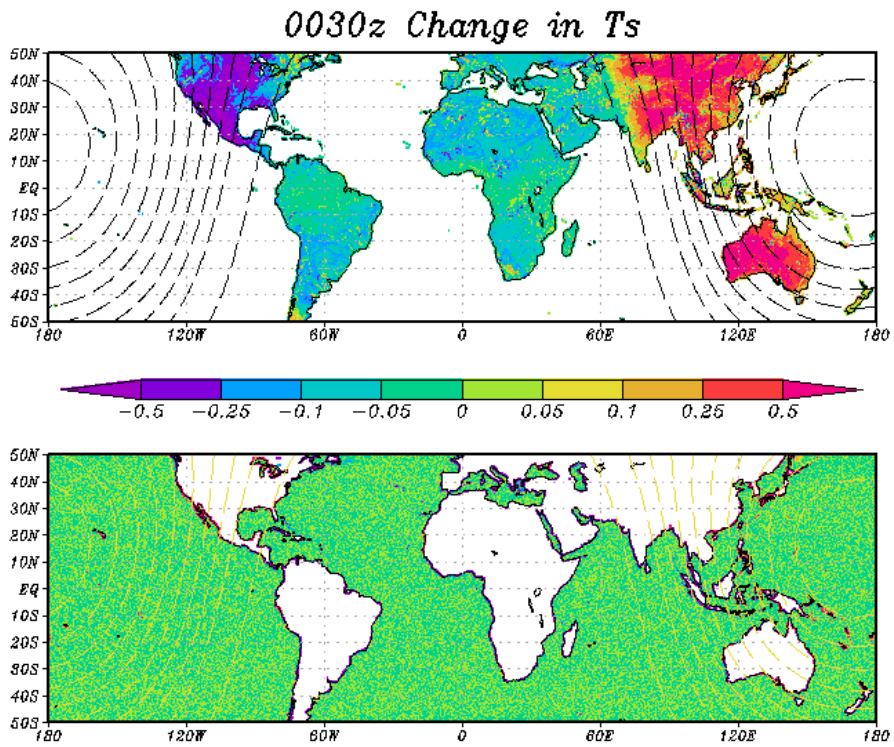
Current status: $\mathbf{T_s}$ over ocean

- Set based on surface boundary conditions, e.g., bulk retrieved "Reynolds SST"
- $\mathbf{T_s}$ has **no** near-surface variability, e.g., diurnal variations
- GSI Analysis (always) includes T_s as a control var, but resulting analysis is **not** used by the model
- SST relevant IR & MW radiance obs are not analyzed, e.g., AVHRR, AMSR, TMI, ...

Important because...

- ⋆ **Air-sea flux** computation requires $\mathbf{T_s}$
- ⋆ **Coupled Atmosphere-Ocean Analysis relies on it**
  Assimilated & bias corrected by GSI ...
- ⋆ **Analysis**: because it is "measured" by satellites via TB
- ⋆ **Time-scale** of evolution is few hours, **not** day(s) like *deep* ocean temperature

Bottom-line: $\mathbf{T_s}$ is more **atmosphere relevant, than to the ocean**.



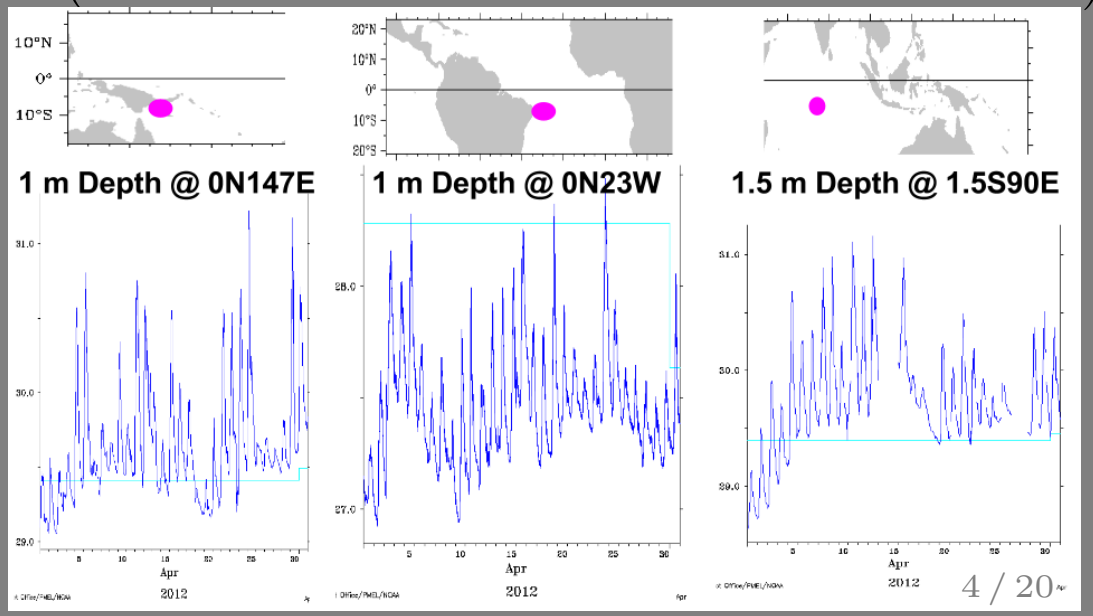
$\mathbf{T_s}$ modeling & Analysis

$\mathbf{T_s}$ = OSTIA SST + $[\mathbf{\Delta T_w} - \mathbf{\Delta T_c}]$; Interface layer *depth* = 2m

- $\mathbf{\Delta T_w}$: solar heating, @ low wind speed, $Max\,\Delta T_w \sim 2 - 3^o K$
- $\mathbf{\Delta T_c}$: a thin cool-skin layer (persistent all day), $\Delta T_c \sim 0.3 - 0.5^o K$
- ★ **Analysis** now includes AVHRR (N-18, METOP-A) 3.7 (night time), 10.7, 12μm
- ◐ Once **coupled** with ocean DAS, ~~OSTIA SST~~ will be swapped out by analyzed temperature

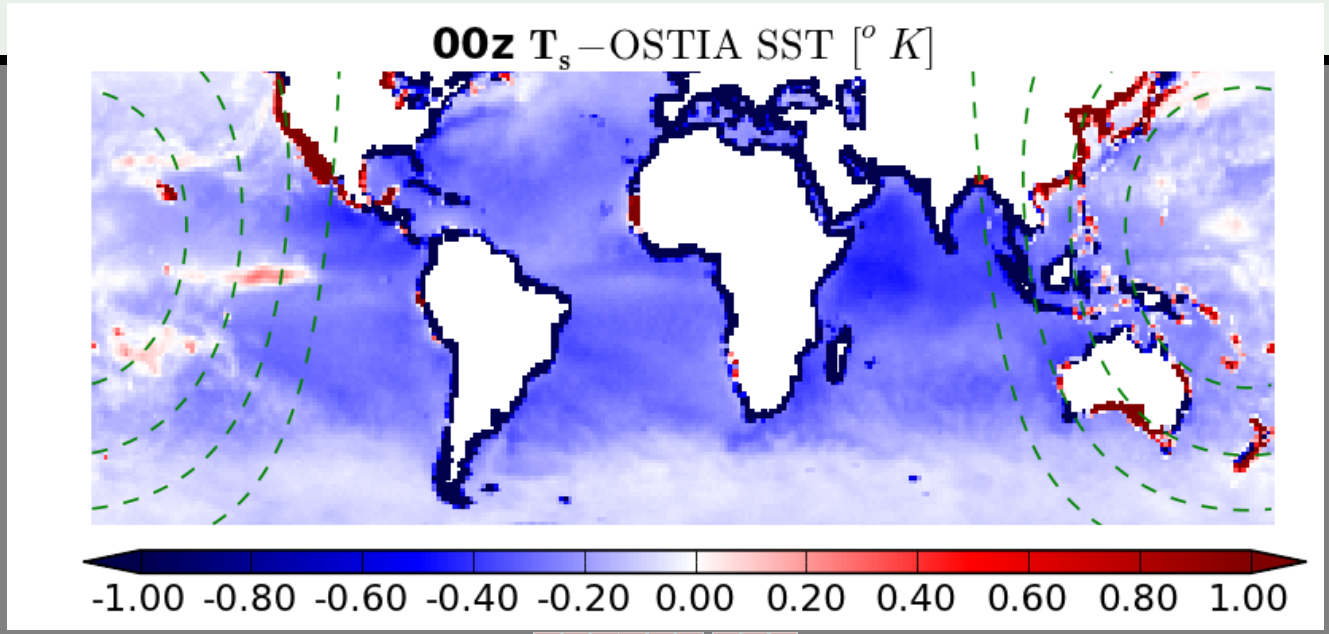
OSTIA SST because . . .

- near-real time availability (1985–), daily @ $1/20^o$
- diurnal warming observations are screened out
- sea-ice concentration is also provided (from EUMETSAT OSI SAF in same file)



$\mathbf{T_s}$ modeling & Analysis (*cont.*)

- $\mathbf{\Delta T_w}, \mathbf{\Delta T_c} = \mathrm{f}$ (heat fluxes, wind speed, ...)
- Trivial extension to ensembles: Atmospheric GCM computes $\mathbf{T_s}, \mathbf{\Delta T_w}, \mathbf{\Delta T_c}$ as prognostic variables
- Change in $\mathbf{T_s} \Rightarrow$ different $\mathbf{T}, \mathbf{q}, \mathbf{p_s}, \mathbf{u}, \mathbf{v}$ (i.e., entire GCM)
- Penetration depth, $z_{ob}(\lambda) = 15\mu\mathrm{m}\ \forall$ IR obstype $\Rightarrow \dfrac{\partial J}{\partial T_s} \equiv 1$



Experiment setup

Exp. Name	$\mathbf{T_s}$	AVHRR obs
CTL	= OSTIA SST	✓
EXP	= OSTIA SST $+[\mathbf{\Delta T_w} - \mathbf{\Delta T_c}]$	✓

- CTL used OSTIA SST as $\mathbf{T_s} \rightarrow$
  Just add AVHRR obs to current system
- **AVHRR** TB observations (GAC): N18 & Metop-A
- **Resolution**: $288 \times 181 \sim 1^o$, 15 day spin up period; Consider 1 month (Apr 2012)
- **in-situ temperature** observations (drifters, buoys) within top 2m were **passive**

Results: *AVHRR OMF time series*

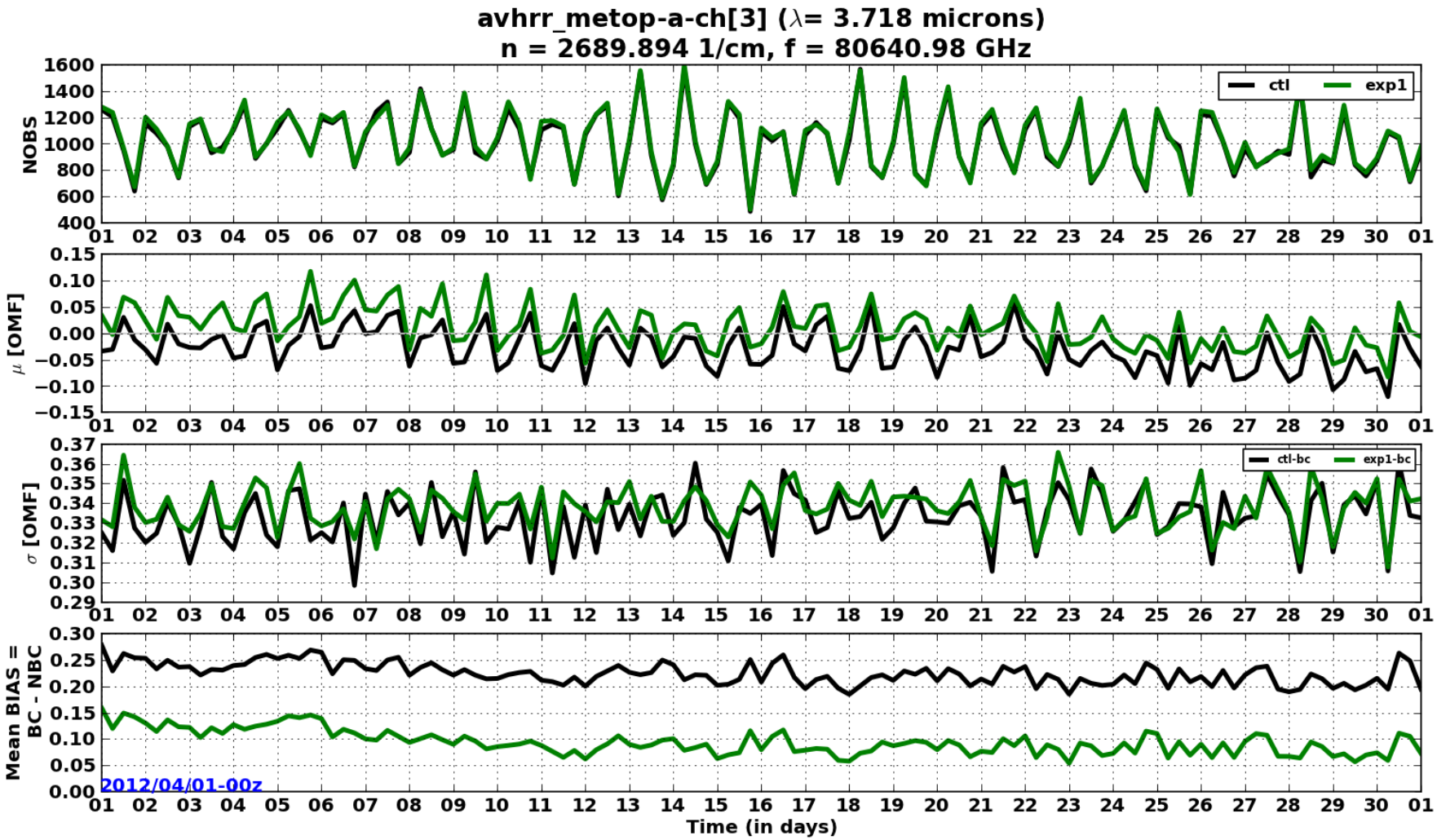
Bias corrected global [Obs – Guess] **Ch.3** *Night time*

Exp Mean[OMF] closer to zero. $\mathbf{T_B}[Ch.3]$ is most sensitive to $\mathbf{T_s}$

steady obs count

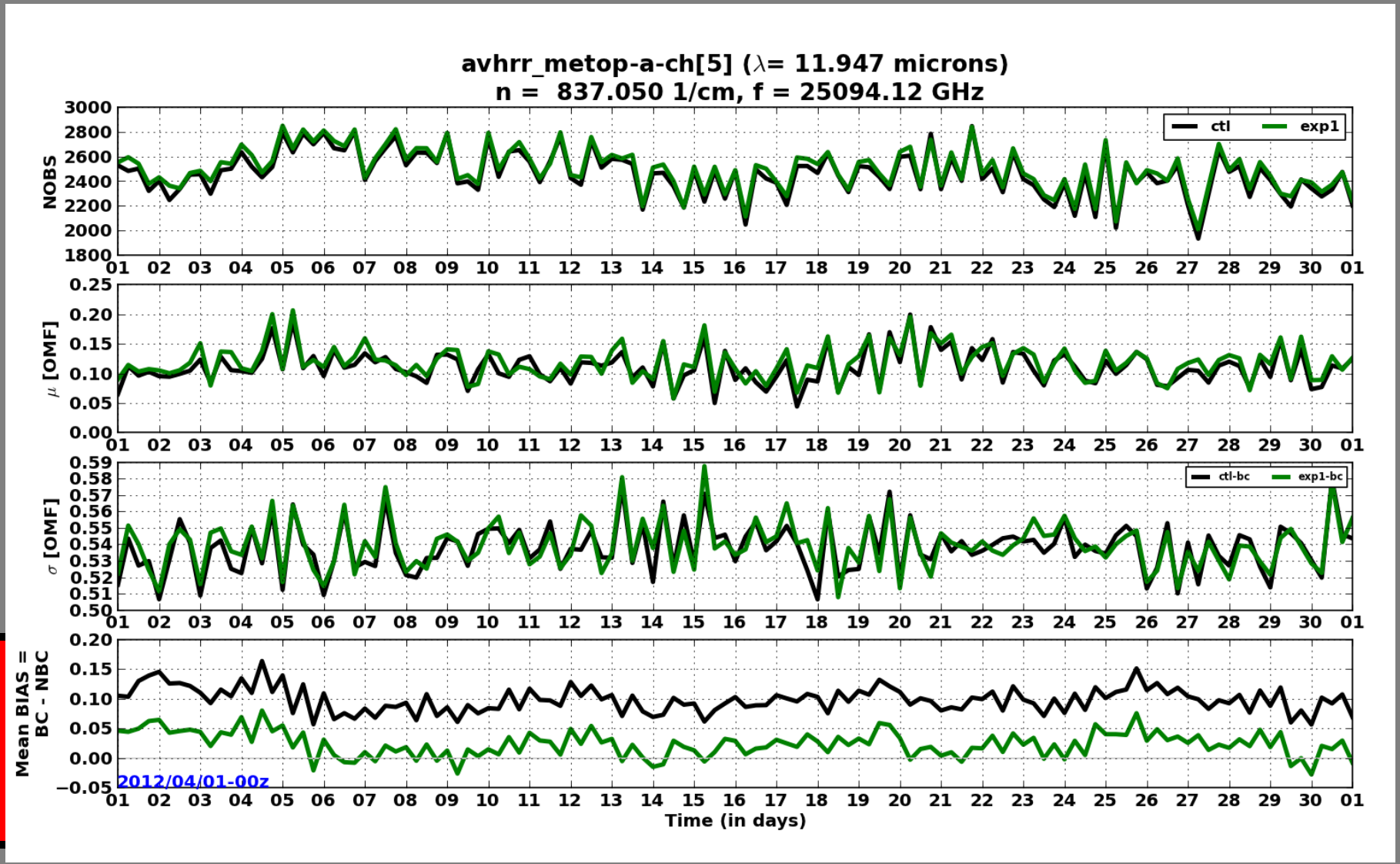
exp: → 0

less bias corr



Results: *AVHRR OMF time series (cont.)*

Ch.5: Water vap contrib to TB



exp: less bias corr

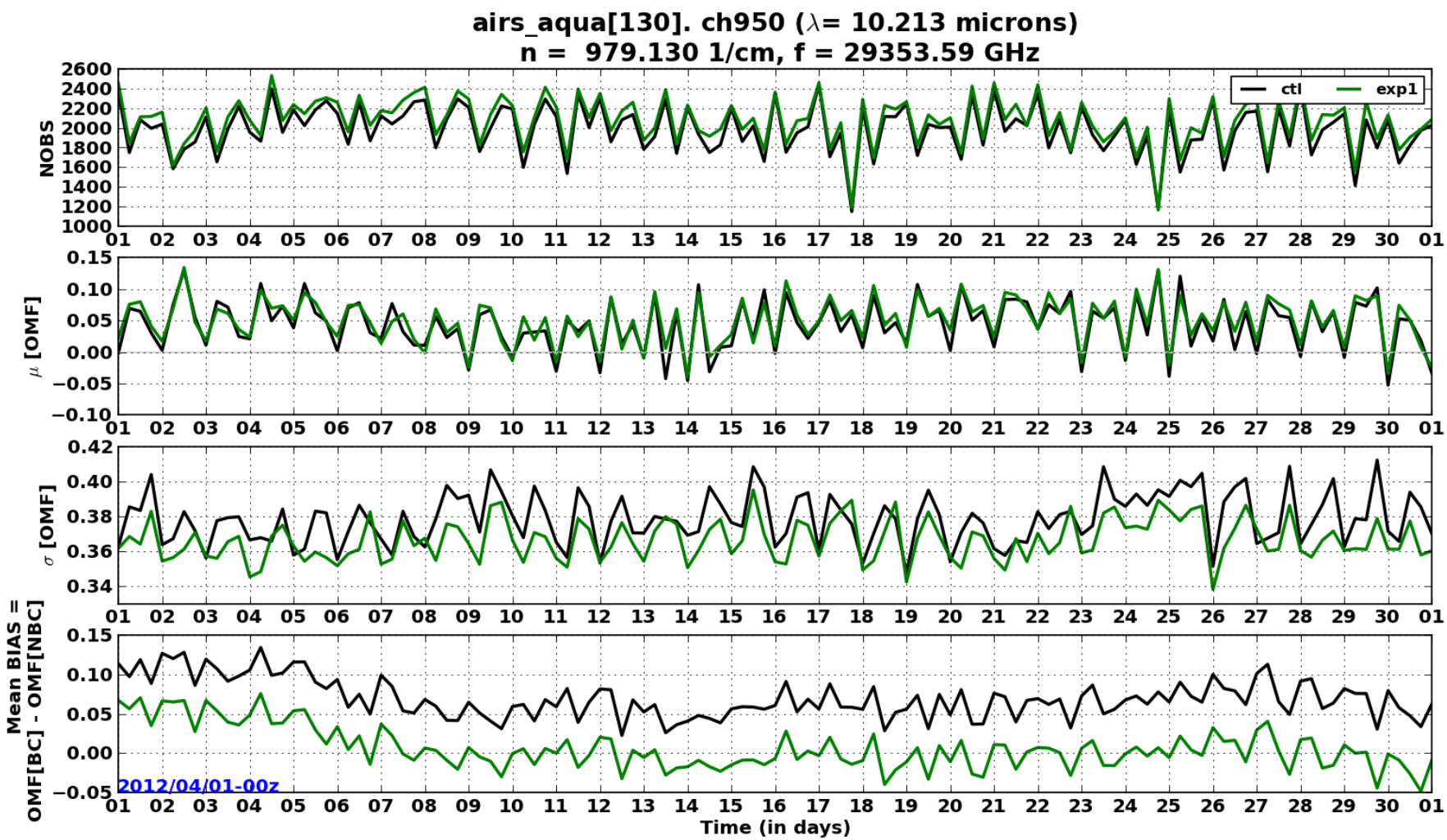
Results: *AIRS-Aqua OMF global ocean*

Impact on existing IR obstypes: Channels that are sensitive to $\mathbf{T_s}$

exp: few more obs

less sdev

less bias corr



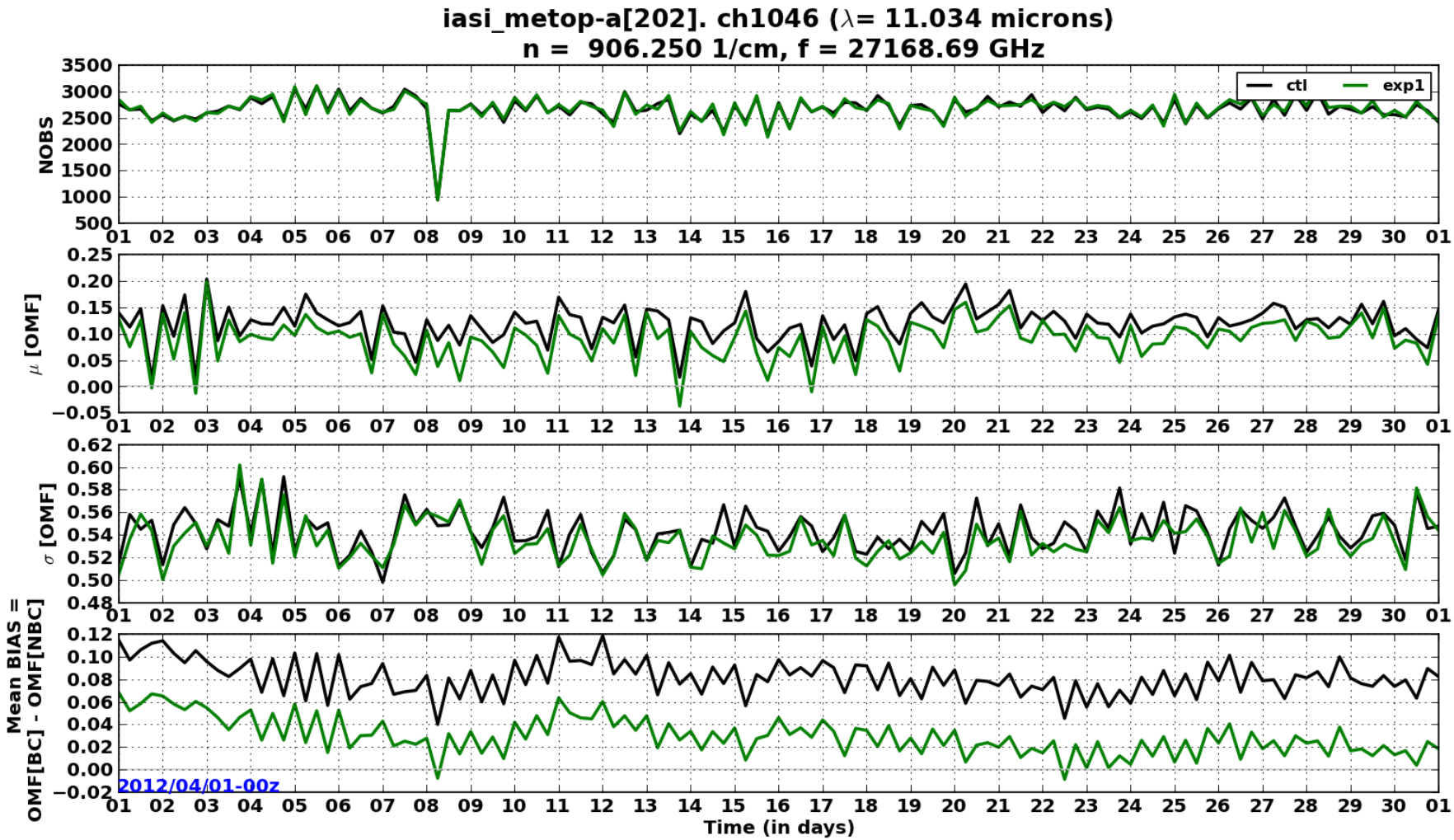
Results: *IASI-Metop-A OMF global ocean*

Impact on existing IR obstypes: Channels that are sensitive to $\mathbf{T_s}$

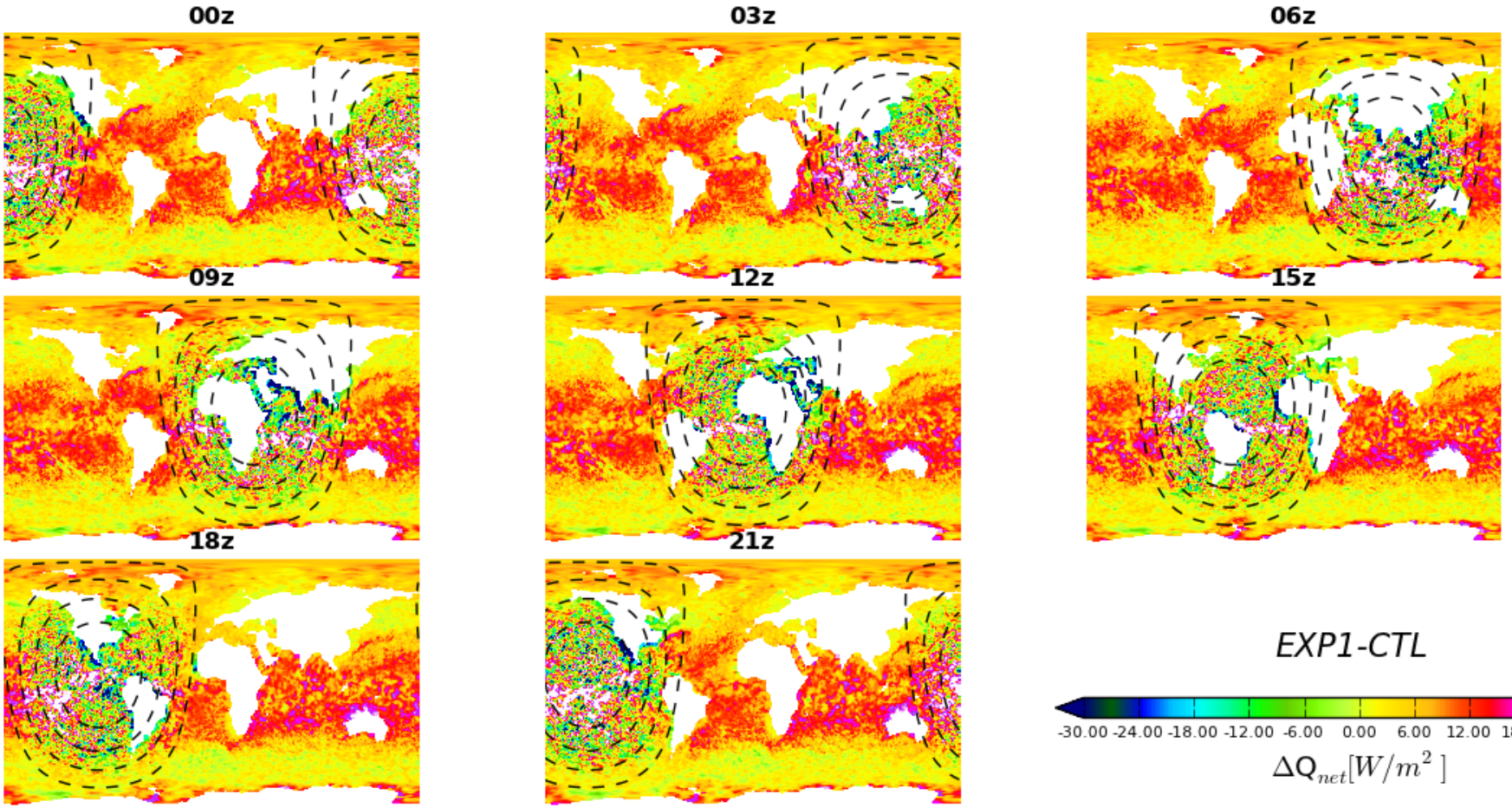
exp: less bias

less sdev

less bias corr



$Q_{net} = SW_{net} - H_s - H_l + LW_{net}$; $LW_{net} = LW_{srf} - sT^4$



Q_{net} @ surface increased: ~10- 20 W/m^2

However, change in SW_{net} ~ 0

Changes are in net

- **LHF**
- **SHF**
- **LW**

Progress Summary

1. Model produces **realistic skin SST** :
   noticeable *changes in net heat flux*

2. All 3 channels of **AVHRR were** *satisfactorily* **assimilated**:
   Mean[OMF] $\rightarrow$ 0 & Std Dev[OMF] $<$ specified σ_o

3. **Improved** (small) **assimilation of $\mathbf{T_s}$ sensitive IR channels**

4. Combination of **modeling ($\mathbf{T_s}$) and analyzing AVHRR**:
   better results than just assimilating AVHRR as in CTL

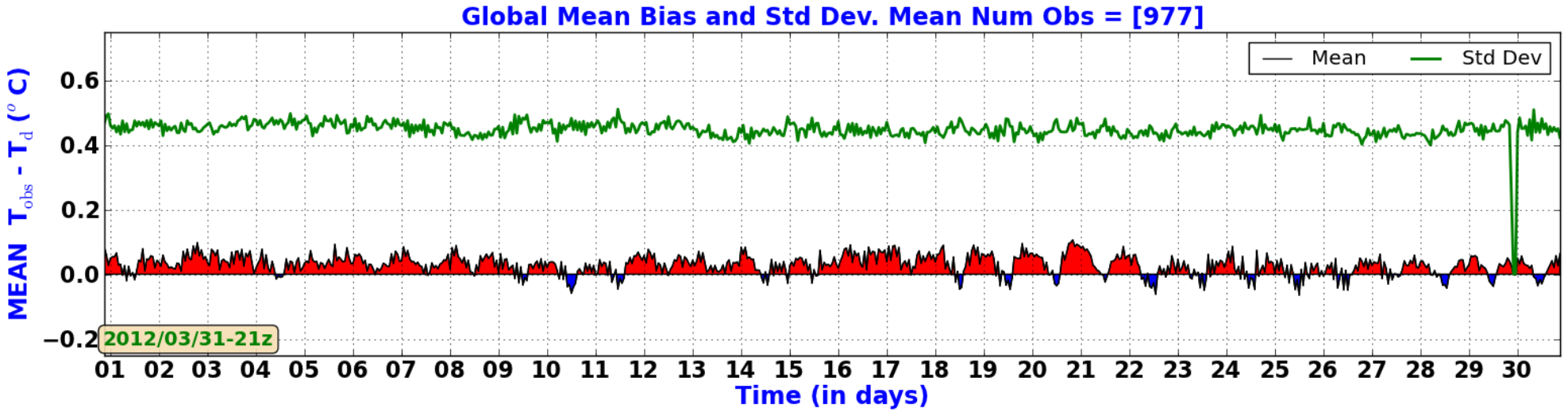
5. **Forecast Skill**:
   Neutral in NH; Improvement (small) in SH

Current Work

1. Extend to include `SST` relevant **MW obs**: TRMM-TMI, GPM-GMI, AMSU-A (ch.:1, 2, 3), ...
2. Evaluate **air-sea fluxes** w.r.t. buoy obs
3. **High resolution** experiments
4. Two-way interaction: of $\mathbf{T_s}$ analysis with **aerosol analysis**

Issues to resolve: in-situ obs bias

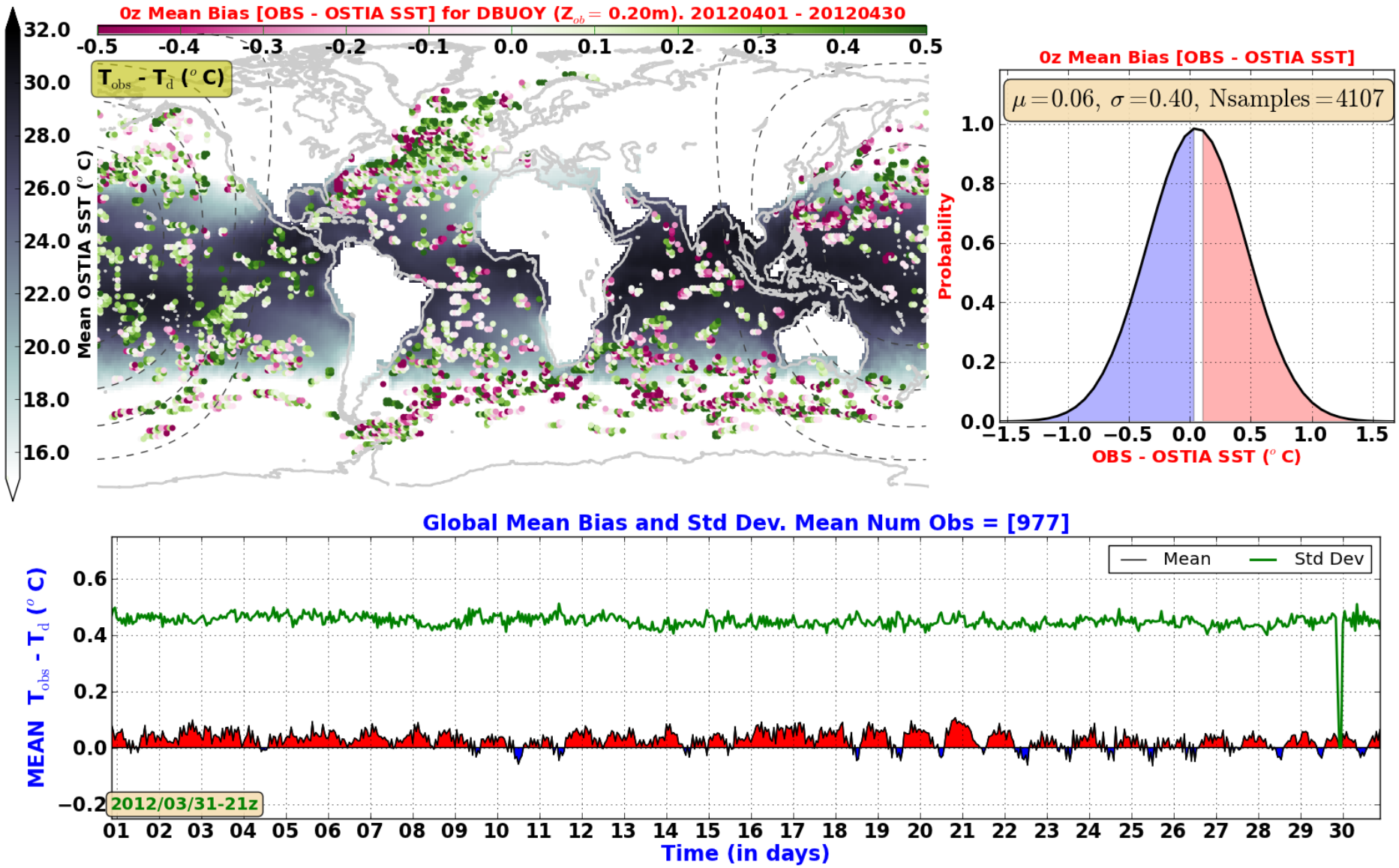
Drifting buoys ($z_{ob} = 20\,\mathrm{cm}$) that were used for OSTIA SST



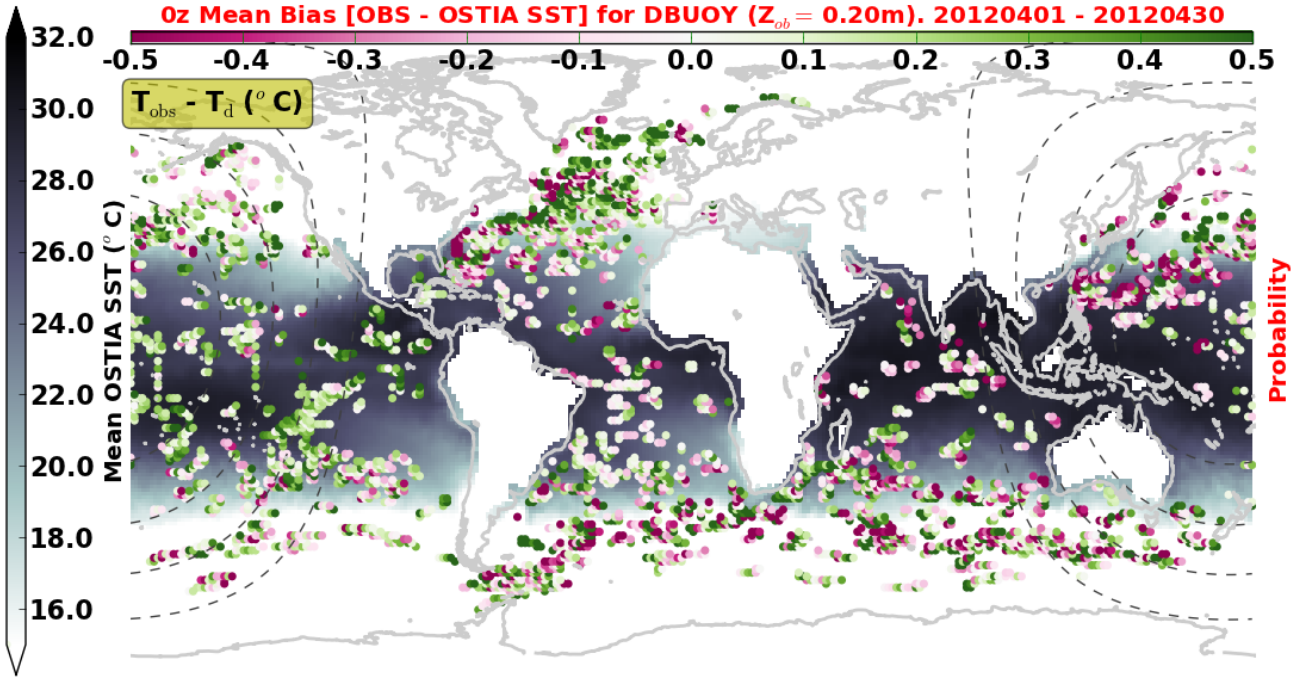
- Global mean bias ~ 0 Good! ☺
- Interesting diurnal biases pop up when we **passively** look closely! ☹

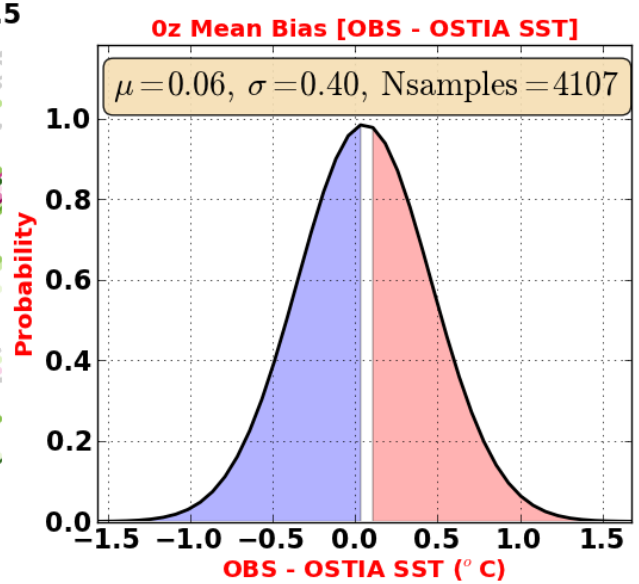
- No observations on 2012/04/29-22z

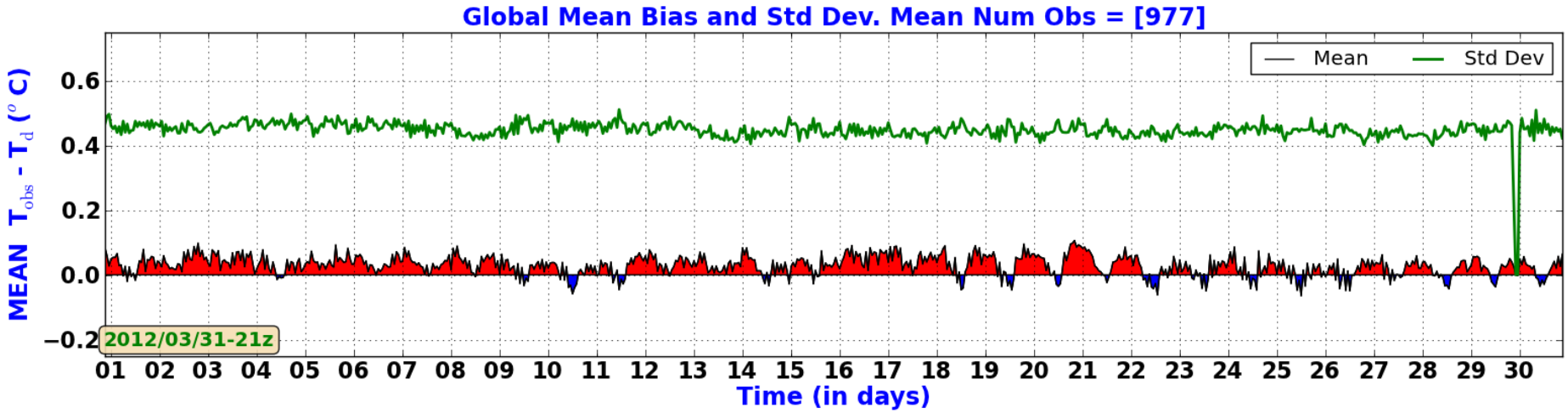
Issues to resolve: in-situ obs bias (00Z)



Issues to resolve: in-situ obs bias (diurnal)







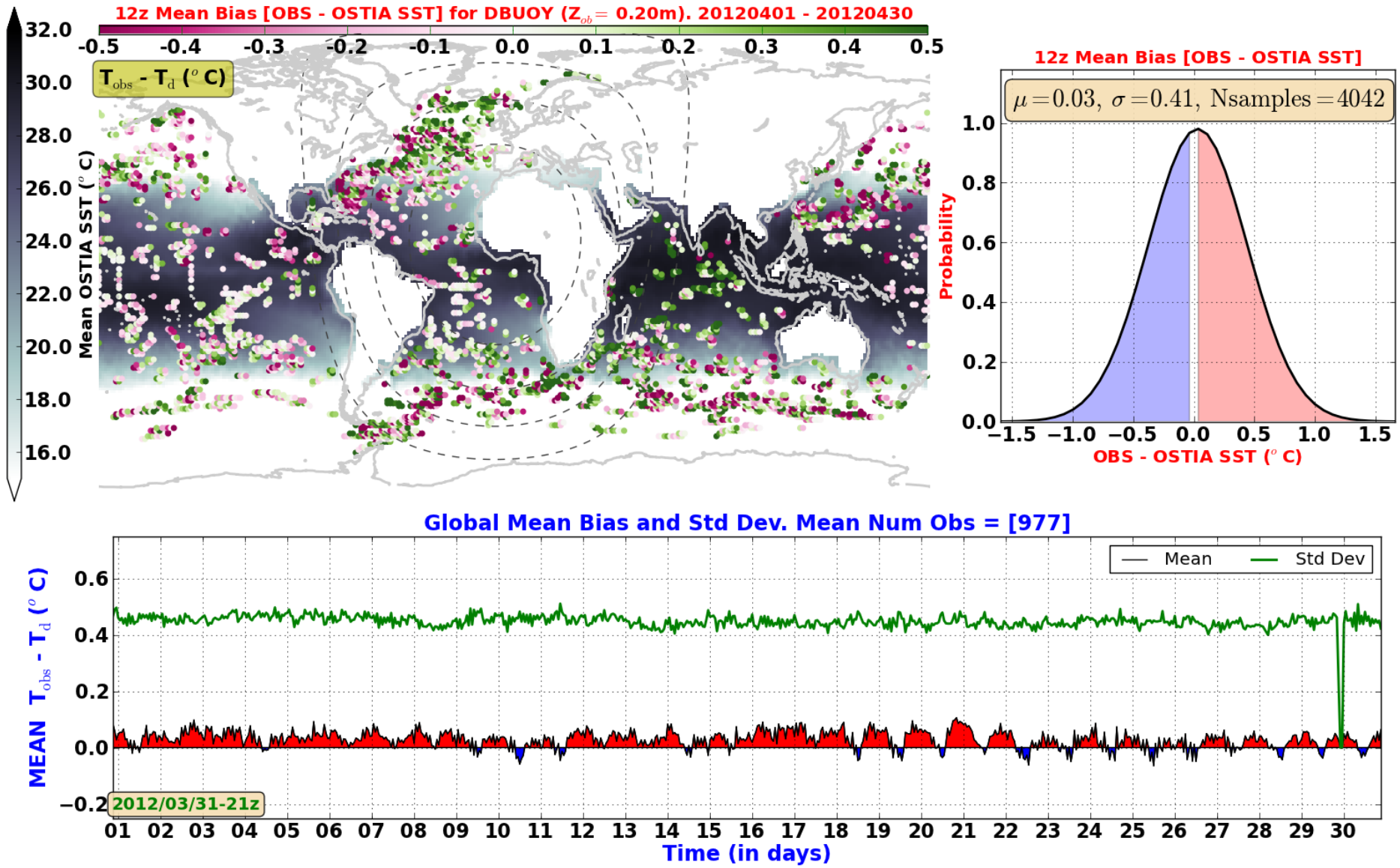
Issues to resolve: in-situ obs bias (diurnal)

- **Night time**: if OSTIA `SST` is **warmer** (pink color)
  cool-skin & IR obs could get us on track!

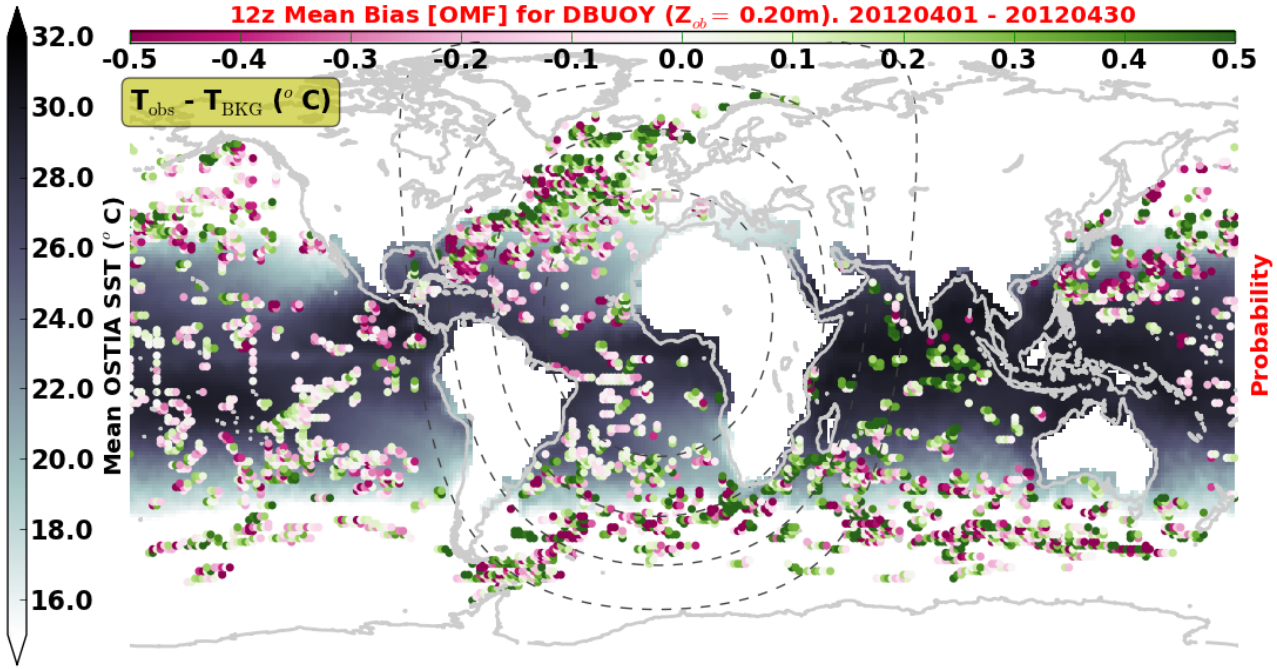
- **Day time**: Obs are warmer than OSTIA `SST` , as desired.
  Recall: day time, low wind speed obs are excluded in OSTIA analysis

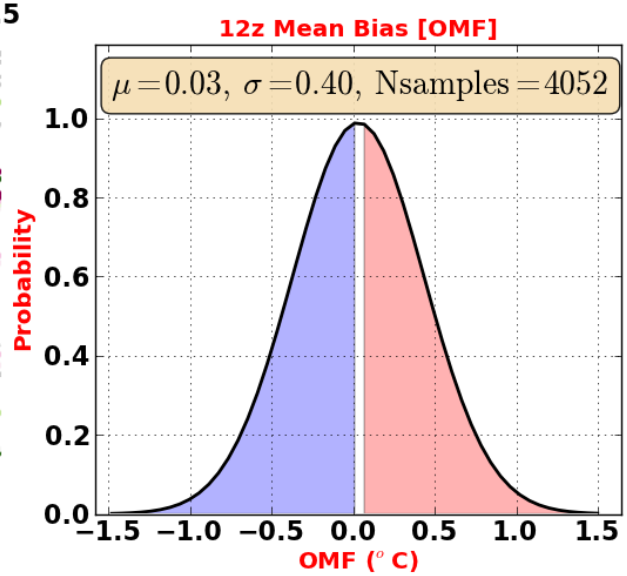
- **Problem**: when OSTIA `SST` $>$ Obs
  we need (MW) data $\rightarrow$ in tropics to fix biases!

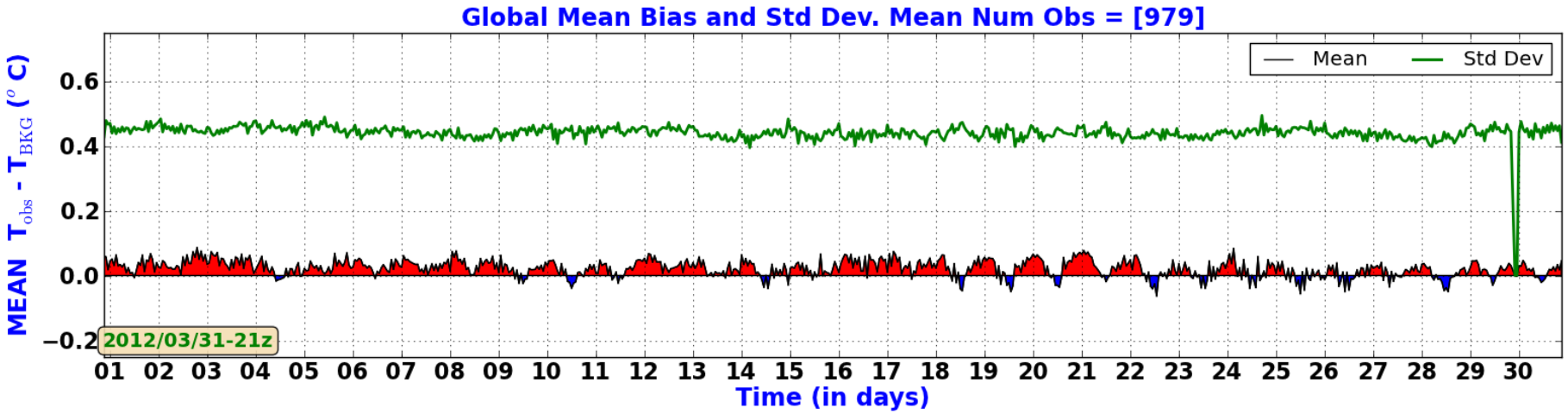
[OBS – $\mathbf{T_d}$] Bias



OMF: [OBS – $\mathbf{T_{BKG}}$] Bias







[OBS – $\mathbf{T_{BKG}}$] Diurnal Bias